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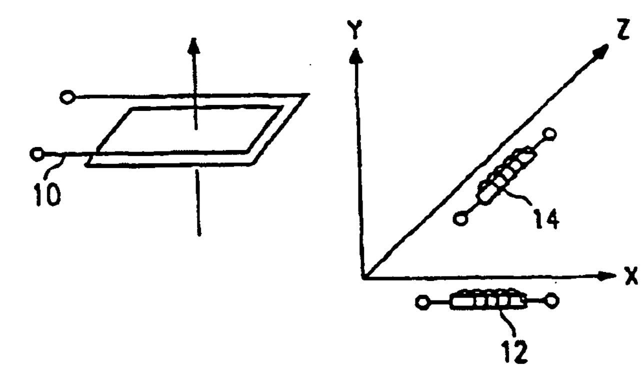
A request for correction of the description has been filed pursuant to Rule 88 EPC. A decision on the request will be taken during the proceedings before the Examining Division (Guidelines for Examination in the EPO, A-V, 3.).

(54) Passive entry x-y-z transponder antenna

(57) In a transponder unit adapted to communicate with an interrogation unit by transmitting RF signals to and receiving RF signals from the interrogation unit, a transponder antenna comprising an elongated tubular first ferrite antenna coil (12), oriented to transmit and receive RF signals a first direction parallel to the barrel of said coil; an elongated tubular second ferrite antenna coil (14), oriented at a different angle from said first coil and adapted to transmit and receive RF signals in a second direction parallel to the barrel of said coil; and a substantially flat, planar air coil (10) adapted to transmit and receive RF signals in a direction perpendicular to the plane of said coil, and oriented at a different angle from said first and said second coils.

FIG. 1



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Description

TECHNICAL FIELD OF THE INVENTION

This invention relates generally to electronic circuits, and more particularly to a passive entry X-Y-Z transponder or reader antenna.

BACKGROUND OF THE INVENTION

The invention relates to an antenna for use in an RF ID or similar transponder comprising a transponder unit which transmits at least one RF interrogation pulse to a remote reader unit which thereupon sends data stored therein back to the transponder unit in the form of a modulated RF carrier.

Such transponder and reader arrangements are appropriate for many applications, including many in which either the transponder or reader unit is mobile, as where either the transponder or reader, or both, are carried by a person, in an automobile or other mobile vehicle, or attached to an animal. When used in these types of applications, the transponder and reader units should be able to effectively receive and transmit RF carrier signals when the transponder unit is oriented in any of a variety of directions and distances relative to the reader unit.

SUMMARY OF THE INVENTION

The effectiveness of conventional antennas for transmission and reception may vary according to a number of factors relating to the antenna environment, including the orientation of the antenna relative to the reader and the modulated RF carrier signal. If a conventional transponder antenna is improperly aligned relative to the reader, the incoming or outgoing RF carrier signal may be degraded and the data represented by the signal misinterpreted.

Therefore a need exists for a transponder antenna which can effectively transmit and receive RF carrier signals from a remote reader unit when the units are oriented in many different directions and distances relative to each other. In accordance with the teachings of the present invention, an omnidirectional transponder antenna is provided which substantially eliminates or reduces disadvantages or problems associated with prior art transponders and antennas.

In particular, a transponder antenna is provided having three antenna coils, one being oriented in each of the X, Y and Z directions. Each coil antenna transmits a dipole type pattern having minima and maxima. Alternatively, two antenna coils may be provided oriented in two planes.

To transmit data from the transponder to a reader unit via an RF carrier, a modulated frequency-shift keying (FSK), phase-shift keying (PSK), or amplitude-shift keying (ASK) oscillator or passive reactance modulator may be used.

In one embodiment, the three antenna coils comprise one preferably flat air coil and two ferrite antenna coils, with the ferrite coils oriented at different angles relative to each other. Each antenna is coupled to a resonant tuning circuit having LC's, and, when the antenna is receiving RF signals, the DC voltages from the tuning circuits are superimposed and added in order to construct a single supply voltage. Alternatively, if the device is oriented in only two directions, one air coil may be used with one ferrite antenna coil.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

FIG. 1 is a graph showing one orientation of an antenna according to the present invention;
FIG. 2 depicts an antenna arrangement according to the present invention;
FIG. 2A depicts an alternative embodiment of an antenna arrangement;
FIG. 3A depicts another alternative embodiment of an antenna arrangement;
FIG. 3 depicts antenna output circuits connected in series;
FIG. 3A is a block diagram of the circuit connected in series;
FIG. 3B is a block diagram of an alternative embodiment having output circuits connected in series;
FIG. 4 depicts antenna output circuits connected in parallel;
FIG. 4A is a block diagram of the circuit connected in parallel;
FIG. 4B is a block diagram of an alternative embodiment having output circuits connected in parallel;
FIG. 5 depicts a reactance modulator circuit for use withe present invention; and
FIG. 6 depicts an active oscillator circuit for use with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 is a graphical representation of one arrangement of antennas according to the present invention. As can be seen from the graph of FIG. 1, one embodiment of the invention comprises an air coil 10, shown here oriented in the Y direction, and one or more ferrite coil antennas. FIG. 1 shows two such ferrite coil antennas 12 and 14, oriented in the X and Z directions, respectively. The ferrite antennas are therefore oriented approximately 90 degrees relative to each other, and from the air coil 10. The ferrite antennas 12 and 14 may be of any conventional construction, such as antennas used in conventional automobile-type transponders.

It will be understood that although the invention will be described below with reference to an embodiment in which the antennas are oriented approximately ninety degrees relative to each other, the precise orientation and alignment of the antennas may be adjusted or mod-

ified as needed to accommodate differing conditions and circumstances, without departing from the spirit and scope of the invention. It will be appreciated by those in the art that certain applications may exist in which satisfactory performance may be achieved with the antennas oriented at angles other than ninety degrees relative to each other.

The individual air coil 10 and the ferrite antenna coils 12 and 14 have a dipole-type pattern with maxima and minima.

It is a technical advantage of the present invention that, by orienting the antennas in this arrangement, and by coupling the antennas as described hereinbelow, a transponder unit is able to effectively receive and reconstruct RF carrier signals which are oriented in any direction relative to the transponder with minimal degradation. In conventional single antenna arrangements having dipole-type patterns with maxima and minima projected in a single plane or axis, the strength of a received RF signal would vary according to whether the antenna was properly aligned in the plane of the signal. Even if the antenna were located adjacent a maxima of the carrier signal, the antenna's ability to receive the signal accurately could be reduced significantly if the antenna were improperly oriented relative to the plane of the signal.

Accordingly, a transponder antenna constructed according to the present invention is suitable for a wide range of applications for which conventional antenna arrangements are inadequate, such as applications in which either the transponder or reader unit, or both, are moveable relative to each other, including, for example, when the transponder or reader units are mounted on vehicles or carried by human beings.

In an alternative embodiment, one air coil antenna may be combined with one ferrite antenna coil in order to provide directionality in two planes, e.g., X + Y, X + Z, or Z + Y. Alternatively, more than three antennas may be used as necessary for improved directionality.

FIG. 2 illustrates an example of three antennas 10, 12 and 14 mounted within a transponder unit in order to achieve the arrangement depicted in the graphical representation of FIG. 1. As shown, ferrite coil antennas 12 and 14 are oriented with the longitudinal axis of the coils oriented in the X and Z directions, respectively. The direction of flux or transmission for ferrite coil antennas lies along this longitudinal axis (in a direction relative to the coil indicated by the "right-hand rule", or parallel to the "barrel" of the generally tubular coil), so that orienting the coils 12 and 14 along these axes will cause the coils 12 and 14 to transmit and receive RF carrier signals along the X and Z axes, respectively.

The air coil 10 is positioned within the transponder unit as shown in FIG. 2. Air coil 10 is a generally flat planar coil which operates such that the direction of flux (the direction in which signals are transmitted from and received by the coil) is perpendicular to the plane of the coil.

As can be seen from FIG. 2, it is a technical advantage of the shown implementation of the present invention that the generally flat planar shape of air coil 10 permits antennas 10, 12 and 14 to be arranged so that the ferrite coils 12 and 14 lie in generally the same plane as air coil 10, so that the antenna arrangement occupies very little space. Since the arrangement depicted in FIG. 2 does not occupy a significant amount of space in the Y-direction, the coil arrangement of the present invention therefore may be used in smaller and thinner (for example, hand-held) transponders than can conventional antenna arrangements, while still enabling the transponder to effectively transmit and receive omnidirectionally.

FIGs. 2A and 2B illustrate alternative embodiments of the present invention in which only one ferrite coil antenna is provided in combination with the air coil 10. FIG. 2A shows the air coil 10 aligned in the Z-direction, in combination with one ferrite coil antenna aligned in the Y-direction. FIG. 2B shows an air coil 10 aligned in the Z-direction in combination with a ferrite air coil aligned in the X-direction. Of course, the alignment of the antennas shown in FIGs. 2, 2A and 2B could be altered without departing from the scope of the present invention.

FIGS. 3 and 4 illustrate arrangements of resonant tuning circuits that may be used with the antennas depicted in FIG. 2. In general, each resonant tuning circuit comprises an inductor, a capacitor, and a diode. Each of the antennas 10, 12 and 14, are coupled independently to a separate resonant tuning circuit, and the three resonant tuning circuits are coupled together either in series, as shown in FIG. 3, or in parallel, as shown in FIG. 4.

FIG. 3 shows three resonant tuning circuits coupled in series. Each resonant tuning circuit comprises an inductor and a capacitor, and the three resonant tuning circuits are coupled together with diodes. Points 20, 22 and 24 indicate where an oscillator and/or modulator circuit (described below) may be coupled when the transponder antenna is adapted to transmit signals. FIG. 3A is a block diagram depicting the antenna arrangement when the circuits are coupled in series.

Alternatively, if only one ferrite antenna coil is used in combination with an air coil, as in FIGs. 2A or 2B, the circuit of FIG. 3 could be easily altered in a manner apparent to those in the art by omitting one of the resonant tuning circuits. FIG. 3B is a block diagram depicting the antenna arrangement when two circuits are coupled in series.

FIG. 4 shows three resonant tuning circuits coupled in parallel. As is the case with FIG. 3, each resonant tuning circuit comprises an inductor and a capacitor, and the three resonant tuning circuits are coupled together with diodes. Points 20, 22 and 24 indicate where an oscillator and/or modulator circuit (described below) may be coupled when the transponder antenna is adapted to transmit signals. FIG. 4A is a block diagram of an an-

tenna arrangement when the circuits are coupled in parallel.

Alternatively, if only one ferrite antenna coil is used in combination with an air coil, as in FIGs. 2A or 2B, the circuit of FIG. 4 could be easily altered in a manner apparent to those in the art by omitting one of the resonant tuning circuits. FIG. 4B is a block diagram depicting the antenna arrangement when two circuits are coupled in parallel.

A similar antenna arrangement may also be provided in a reader unit, in order ro provide omnidirectionality at a remote location.

In operation, when the transponder is used to receive RF carrier signals transmitted from a remote location, the three antennas 10, 12 and 14 operate to independently receive components of the carrier signal oriented in the Y, X and Z directions, respectively. The received signals are passed to the resonant tuning circuit connected to each antenna. The series arrangement of the resonant tuning circuits shown in FIG. 3 act to superimpose and add the DC voltage components of the received carrier signal, to reconstruct the signal components into a single DC voltage signal representative of the signal which was transmitted from the remote location. The parallel arrangement of the resonant tuning circuits shown in FIG. 4 operates such that the highest induced voltage either supplies all RF circuits, or supplies only the RF circuit having the highest individual voltage.

In this manner, an RF carrier signal transmitted from a remote location may be accurately reconstructed even if the signal is oriented in a peculiar manner relative to the transponder. In addition, the use of an air coil 10 and two ferrite coils 12 and 14 oriented in the manner described above enables the entire arrangement to be positioned inside a very small space, so that the antenna arrangement herein described may be used in a small, hand-held or pocket-sized transponder.

When the transponder is used to transmit RF signals, each of the antennas 10, 12 and 14 may be independently coupled either to a modulated oscillator, or to a passive reactance modulator. FIG. 5 shows a reactance modulator circuit configured in a full-duplex, back scatter mode, that may be coupled to each of the antennas 10, 12 or 14, and FIG. 6 shows a circuit for a modulated active oscillator which may also be used.

In one arrangement of the present invention, a similar antenna arrangement may be provided in a reader unit which transmits an omnidirectional energy field to the transponder unit. The transponder unit uses the received energy to generate a data signal, either by modulating a RF signal onto the received field via the passive reactance modulator of FIG. 5, or by receiving the energy and operating an active oscillator as shown in FIG. 6, and utilizing the received energy to project its own field.

Alternatively, since reader units typically require more power than transponder units, the reader unit may be provided with two or three air coil antennas oriented in different directions, instead of a single air coil in combination with one or two ferrite coil antennas.

While the present invention has been described in detail with reference to the above embodiments, it should be understood that various changes, modifications and substitutions can be made without departing from the spirit and scope of the invention as defined by the appended claims.

Claims

1. A transponder antenna, comprising:

   a first ferrite antenna coil, oriented in a first direction and coupled to a first circuit;
   an air coil antenna, oriented in a second direction at an angle different from said first direction, and coupled to a second circuit;
   wherein RF signals received by said first antenna coil and by said air coil are processed by said first and second circuits, respectively, to generate DC signals representative of the signal received by each of said antennas.

2. The transponder antenna of claim 1, wherein said first antenna coil and said air coil antenna are oriented approximately ninety degrees relative to each other.

3. The transponder antenna of claim 1, wherein said first and second circuits comprise resonant tuning circuits connected in series.

4. The transponder antenna of claim 1, wherein said first and second circuits comprise resonant tuning circuits connected in parallel.

5. The transponder antenna of claim 1, further comprising a second ferrite antenna coil oriented in a third direction different from said first and second directions, and coupled to a third circuit.

6. The transponder antenna of claim 5, wherein said first ferrite antenna coil, said second ferrite antenna coil, and said air coil are oriented approximately ninety degrees relative to each other.

7. The transponder antenna of claim 5, wherein said first, second and third circuits comprise resonant tuning circuits connected in series.

8. The transponder antenna of claim 5, wherein said first, second and third circuits comprise resonant tuning circuits connected in parallel.

9. The transponder of claim 1, further comprising:

a first output circuit coupled to said first ferrite antenna coil; and
a second output circuit coupled to said air coil.

10. The transponder of claim 9, wherein said first and second output circuits comprise passive reactance modulators.

11. The transponder of claim 9, wherein said first and second output circuits comprise active oscillators.

12. A transponder unit adapted to communicate with an interrogation unit by transmitting RF signals to and receiving RF signals from the interrogation unit, comprising:

an elongated tubular first ferrite antenna coil, oriented to transmit and receive RF signals a first direction parallel to the barrel of said coil;
an elongated tubular second ferrite antenna coil, oriented at a ninety degree angle from said first coil and adapted to transmit and receive RF signals in a second direction parallel to the barrel of said coil; and
a substantially flat, planar air coil adapted to transmit and receive RF signals in a direction perpendicular to the plane of said coil, and oriented at a ninety degree angle from said first and said second coils.

13. The transponder antenna of claim 12, further comprising:

a first circuit coupled to said first antenna;
a second circuit coupled to said second antenna; and
a third circuit coupled to said air coil;
wherein RF signals transmitted from or received by said first and second antennas and said air coil are processed independently by said first, second and third circuits.

14. A system for remote communication, comprising:

a transponder unit having a receiving antenna; and
a reader unit disposed at a location remote from said transponder unit, comprising:
a first antenna coil, and
an second antenna coil oriented at an angle relative to said first antenna coil;
wherein said reader unit is adapted to transmit an energy field to said transponder unit via said first antenna coil and said second antenna coil.

15. The system of claim 14, wherein the reader unit further comprises a third antenna coil oriented at an angle relative to said first antenna coil and said second antenna coil.

16. The system of claim 14, wherein the transponder unit further comprises at least one passive reactance modulator coupled to said receiving antenna for modulating a signal onto the energy field received from said reader unit.

17. The system of claim 14, wherein the transponder unit further comprises at least one active oscillator coupled to said receiving antenna for receiving and storing the energy field received from said reader unit.

18. The system of claim 14, wherein said first antenna coil is an air coil.

19. The system of claim 18, wherein said second antenna is a ferrite coil antenna.

20. The system of claim 18, wherein said second antenna is an air coil.

FIG. 1

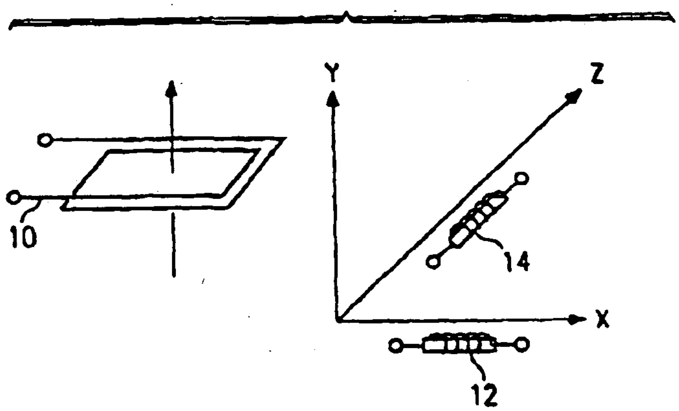


FIG. 2

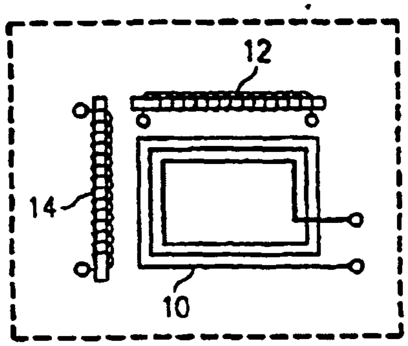


FIG. 3

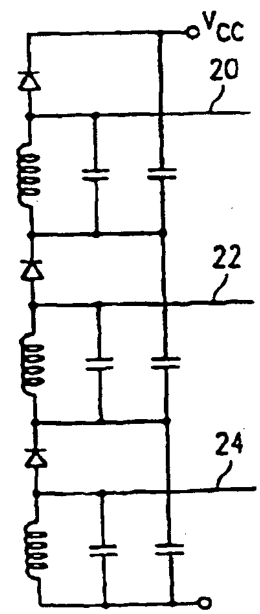


FIG. 4

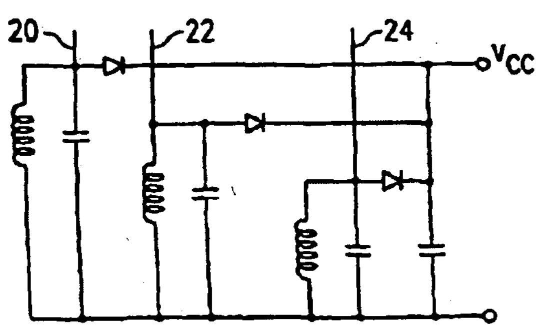


FIG. 2a

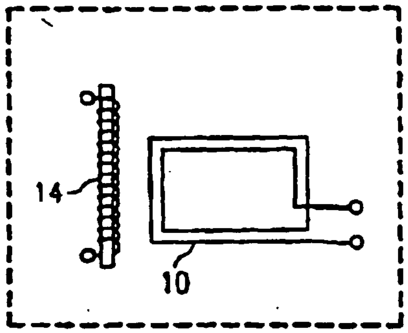


FIG. 2b

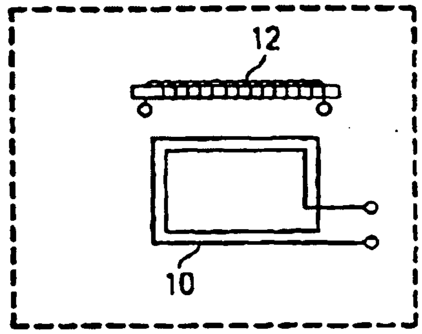


FIG. 5

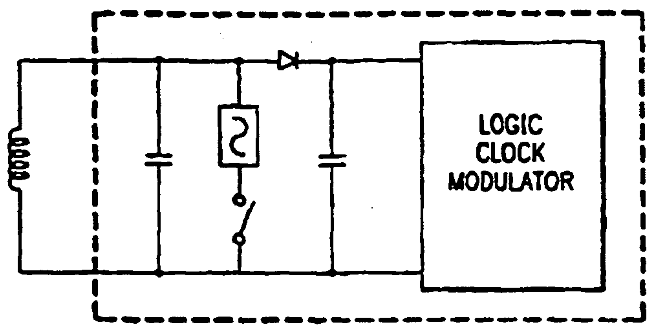


FIG. 6

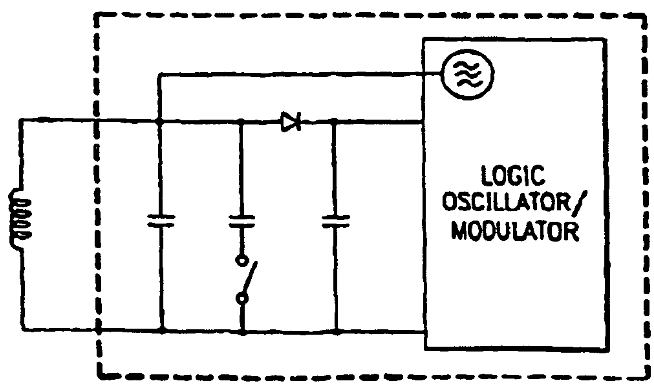


FIG. 3a

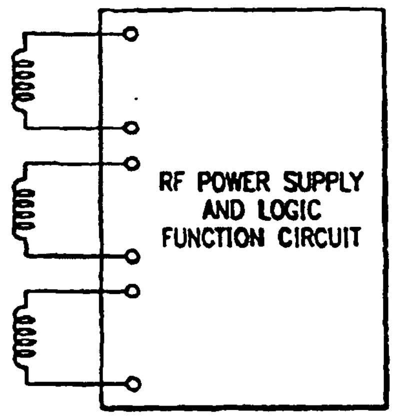


FIG. 4a

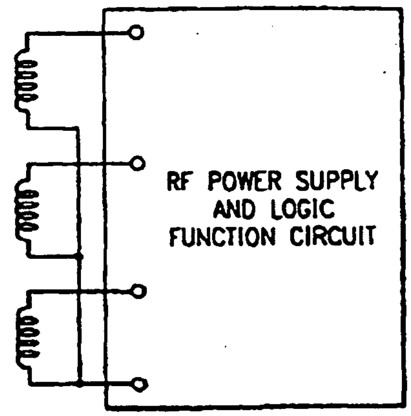


FIG. 3b

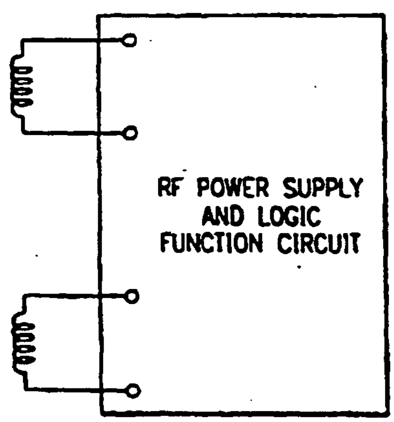
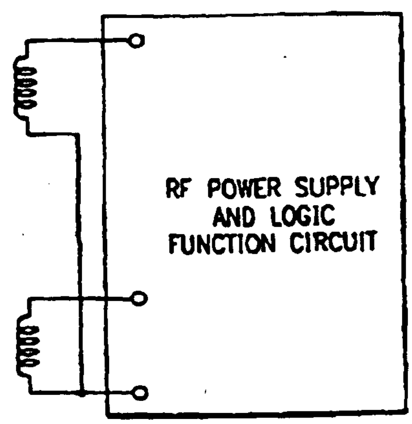


FIG. 4b



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EUROPEAN SEARCH REPORT

Application Number
EP 97 10 0021

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X Y	EP 0 689 301 A (TELEDIFFUSION FSE) 27 December 1995 * column 1, line 1 - column 4, line 56; figures 2A-2F,3,5 *	1-20 3-8,12, 13,15,19	H01Q21/28 H01Q7/00
Y	PATENT ABSTRACTS OF JAPAN vol. 010, no. 046 (E-383), 22 February 1986 & JP 60 201702 A (MATSUSHITA DENKI SANGYO KK), 12 October 1985, * abstract *	6,12,15	
A	DE 41 05 826 A (VALEO SECURITE HABITACLE) 5 September 1991 * column 3, line 17 - column 3, line 61; figure 1 *	1,2,5,6, 12,14, 15,18-20	
Y	DE 29 48 033 A (JAUCH DR HEINZ) 4 June 1981 * page 7, line 19 - page 7, line 27; figures 1-3 *	3-8,12, 13,15,19	TECHNICAL FIELDS SEARCHED (Int.Cl.6)
A	US 4 278 980 A (OGITA MINORU ET AL) 14 July 1981 * column 1, line 50 - column 2, line 7 * * column 5, line 10 - column 5, line 25; figures 1,8 *	1,12,14	H01Q
A	EP 0 350 006 A (NIPPON ELECTRIC CO) 10 January 1990 * column 4, line 30 - column 5, line 32; figure 7 *	1,2,9, 12,14	
A	US 4 155 091 A (VORIE GILBERT C) 15 May 1979 * column 2, line 18 - column 2, line 38; figure 1 * -/--	1,2,12, 14	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	6 March 1997	Cannard, J-M

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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L : document cited for other reasons

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DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
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A	EP 0 414 628 A (KALTNER GEORGE W) 27 February 1991 * column 2, line 5 - column 4, line 54; figures 1,2 * -----	1,4, 12-14,20	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)

The present search report has been drawn up for all claims

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L : document cited for other reasons
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